Etymology. Named after Denis O'Meara who, around 1980, drew my attention to this spectacular plant. Denis has undertaken a number of surveys to determine the geographic range of the new variety. He has successfully hrought it into cultivation in his extensive native plant arboretum at Marble Bar.

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SEEDLINGS OF AUSTRALIAN CASUARINAS I. GERMINATION

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ABSTRACT

Germination in 37 *Casuarina* (including *Allocasuarina*) species was studied and the results compared with previous records. The nature of a mesocarpic water-absorbing structure at the casuarina samara is discussed and two simple methods for germination are proposed.

INTRODUCTION

The germination of casuarina seed (samaras) is considered to be relatively easy (Elliot & Jones 1982). Turnbull and Martensz (1982, 1983) recommended a three-month post-ripening period before sowing, with most species benefitting from daily exposure to light during germination. Kuo (1984) reported that a 24-hour soaking in running water improved the germination of two species. On the other hand, cold, moist stratification was found to confer no apparent advantage to the germination of *C. cunninghamiana* (Jakimova 1965).

Previous germination substrata range from filter paper (Clemens *et al.* 1983), plastic sponge strips overlain by filter paper (Turnbull & Martensz 1982), river sand (Chuk 1983), coarse sand (Reddell & Bowen 1985), a saw-dust/sand mixture (Kuo 1984), perlite (Torrey 1976), vermiculite (Shepherd & El-Lakany 1983) to an unspecified "open, well-drained" medium (Elliott & Jones 1982).

Once wet, the samaras of many species become sticky due to the presence of a water-absorbing structure, the exact nature of which has been variously reported. It was first recorded as a mucilaginous gel (Mott & Groves 1981) and later as an elaborate polysaccharide (Turnbull & Martensz 1982). In addition, the structure was located on the testa by several authors (Turnbull & Martensz 1982; Langkamp & Plaisted 1987).

The aims of this study were to explore simpler germination methods in the sense of reducing the cost of labour or equipment, and to compare the present results, particularly the time required for germination, with previous reports. The nature of the water-absorbing structures on the samara was also investigated.

Although Johnson (1980, 1982, 1988) and Wilson and Johnson (1989) have divided *Casuarina sens. lat.* into four genera: *Casuarina*, *Allocasuarina*, *Gymnostoma* and *Ceuthostoma*, studies by Dilcher *et. al.* (1990) and Hwang (1989) have failed to clearly distinguish *Allocasuarina* from *Casuarina* for a range of micromorphological and seedling characters. For this reason, those species referred by Johnson to Allocasuarina have been retained here as *Casuarina*.

MATERIALS AND METHODS

Seeds of 105 specimens were obtained from various sources (see Appendix). A gauze-covered beaker of seeds was placed overnight under running tap water, then the seeds were spread on a wet fibrous pad (Figure 1). They were placed in a glasshouse under natural lighting, and an evaporative air cooler was automatically activated when the temperature reached 30°. The number of days to first germination was recorded, where germination was defined as the emergence of the radicle (Turnbull & Martensz 1982).

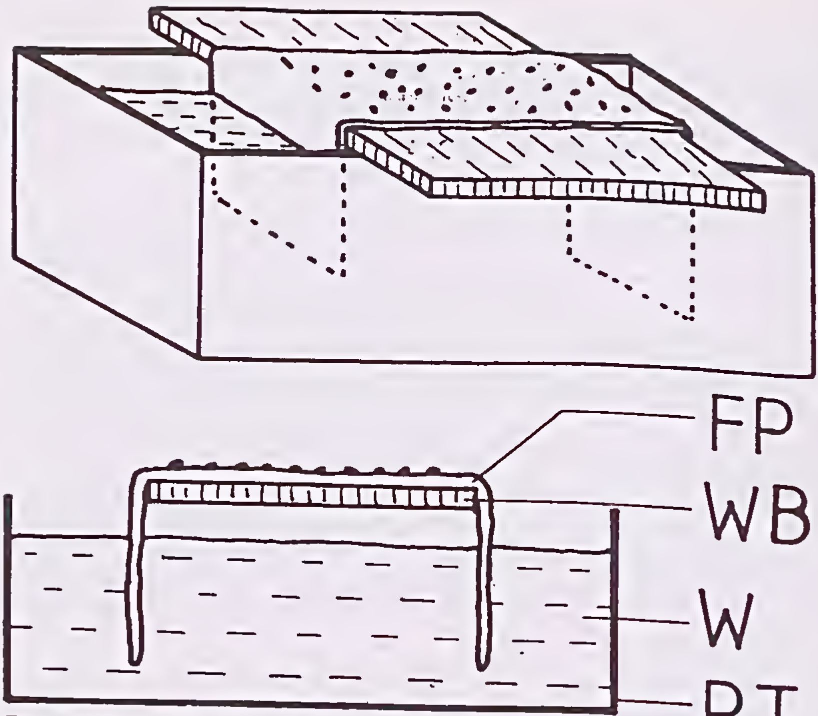

Figure 1. Germination design, FP, fibrous pad made of 3-ply cotton gauze and 1-ply (top) towel tissue; PT, plastic tray; W, water; WB, wooden board.

Samara Appendages

Material of the water-absorbing structure was removed from the samaras of each species, moistened with distilled water, and mounted under a light transmission microscope.

RESULTS

Germination

The time to the first germination for each specimen is listed in the Appendix. In general, the time recorded by Kullmann (1981) was longer than other reports (Table 1) although the difference was only significant ($x^2 p < 0.05$) for four of the species. The results from Turnbull and Martensz (1982) are similar to the present study for comparable species.

Three medium-relevant factors affect the germination of casuarinas: water, air and light. Sand or sandy media have only the advantage of air supply, whereas vermiculite and analogous materials have the advantage of both water and air. Filter paper has all the above advantages plus ease of observation, but if placed in a closed petri dish, the chance of fungal attack is enhanced. In contrast, if the petri dish is left open, then there will be problems with water supply.

In the present study we used the design shown in Figure 1 which incorporates every advantage. It is suggested that the wooden board (Figure 1; plastic can be used if there are no chemical exudates) covers as much of the water surface as possible to reduce evaporation (the size shown in Figure 1 is for convenience of illustration). The plastic tray should ideally be black to reduce algal growth in the water. The wick/pad can be made of

Table 1. Days to the first germination of Australian casuarinas

Species	This Study	Kullmann (1981)	Turnbull & Martensz (1982)	x^2_c	df	P
Casuarina						
acuaria	18	18	-	0.03	1	n.s
acutivalvis	10.3	14	14	0.72	2	n.s
campestris	6.5	14	8	3.31	2	n.s
corniculata	14.3	16	-	0.16	1	n.s
cristata	9.7	7	7	0.90	2	n.s
cunninghamiana ssp. *cunninghamiana*	5	-	5	0.03	1	n.s
cunninghamiana ssp. *miodon*	6	-	-	-	-	-
decaisneana	4	14	5	7.91	2	0.05
decussata	14	20	14	1.50	2	n.s
dielsiana	4	11	5	4.23	2	n.s
distyla	6.7	-	-	-	-	-
equisetifolia	15	-	5.5	3.52	1	n.s
fraseriana	18.5	20	10	3.60	2	n.s
glauca	10.3	-	7	0.31	1	n.s
helmsii	8	16	-	3.38	1	n.s
huegeliana	5.5	14	7	4.66	2	n.s
humilis	7	14	7	5.83	2	n.s
inophloia	6	-	-	-	-	-
lehmanniana	11.7	18	7	4.98	2	n.s
littoralis	5.9	-	5	0.00	1	n.s
leuhmannii	8	-	7	0.00	1	n.s
microstachya	6	*2	-	9.48	1	0.01
monilifera	9	-	-	-	-	-
muelleriana	13.4	-	-	-	-	-
nana	9	-	-	-	-	-
obesa	7	*17	5	8.56	2	0.05
oligodon	7	-	-	-	-	-
paludosa	9.7	-	-	-	-	-
paradoxa	10	-	-	-	-	-
pinaster	17	20	-	0.43	1	n.s
pusilla	13.7	-	-	-	-	-
scleroclada	9	*22	-	6.32	1	0.05
striata	11.2	-	-	-	-	-
tessellata	9.3	17	14	2.24	2	n.s
thuyoides	11	14	-	0.64	1	n.s
torulosa	7	-	5	0.08	1	n.s
trichodon	9	18	-	3.70	1	n.s
verticillata	6.3	-	7	0.22	1	n.s

* significantly different
x^2_c using Yate's correction (Zar 1984).

any fibrous material (such as cheese cloth), as long as its thickness ensures a good water supply on hot days. An extra advantage of this design is that the large amount of water acts as a temperature buffer by absorbing heat during the day and releasing it during the night when the temperature is lower. Although different species have different optimal germinating temperatures (Turnbull & Martensz 1982), in general most species will germinate without special treatment.

An interesting germination feature observed during this study involved germinating seeds under water. Many of the species tested were found to germinate successfully under water, and this method may prove to be one of the most efficient, although further study is needed. The main problem with this method is that the seedlings need to be removed from the water as soon as possible. How long they can stay in water after germination is still uncertain, although seedlings with a 10mm taproot were still alive.

DISCUSSION

Samara Appendages

The water-absorbing structure was found to occur mainly around the transition zone between the wing and nutlet, and microscope examination revealed numerous coiled fibres superficially resembling tubular worms (Figure 2). It is this hollow tube which holds the water. When torn, the

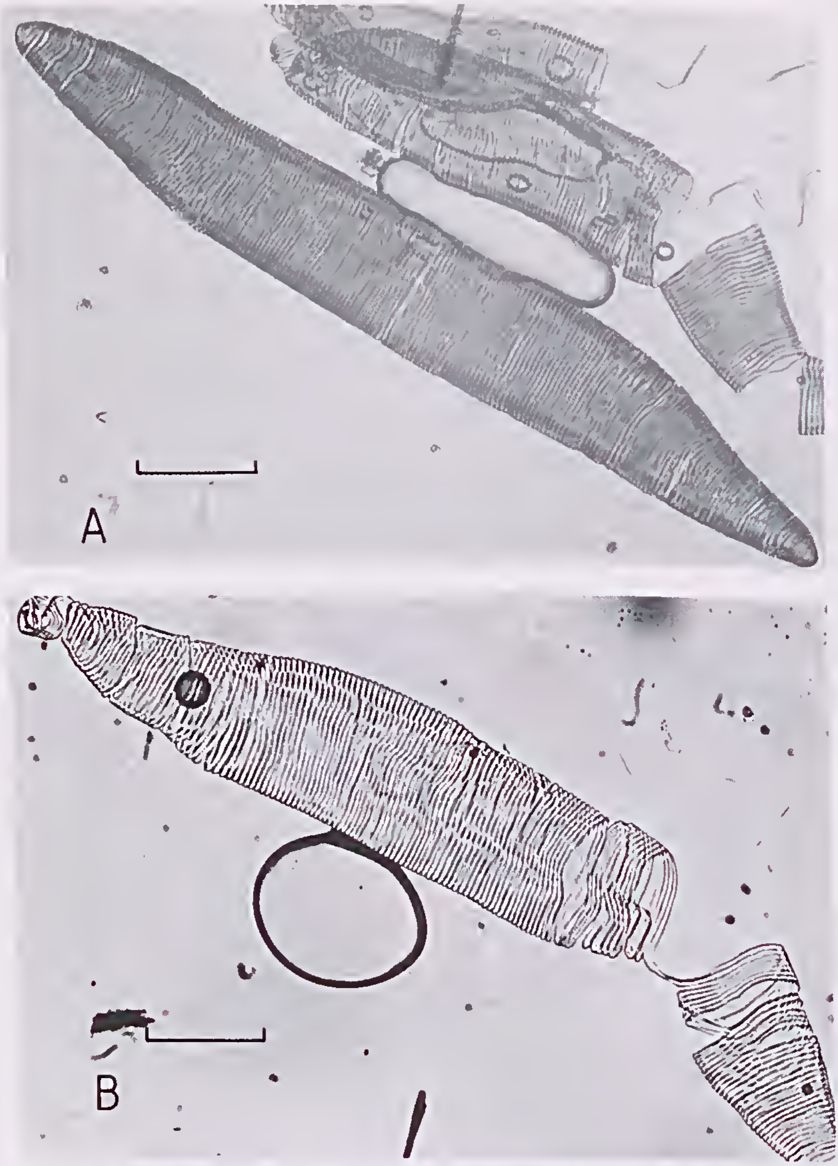

Figure 2. Coiled mesocarpic fibres of C. *decaisneana*. Scale bar — 40 um. A: an intact fibre and several torn ones. B: a partly uncoiled fibre.

fibres uncoil at the torn ends. As *Casuarina* "seeds" are samaras, the "seed coat" and thus the fibres are of mesocarpic origin. Ladd (1989) in an independent study also reached this conclusion.

Mott & Groves (1981) postulated that the fibres help with seedling anchorage, and we suggest that they also help to detach the wing, which is not required during germination. The wing, in addition to its role in airborne dispersal agent, also acts as a flotation device if the seed lands on water.

The amount of fibres, and the coil shape also appear to have some use as taxonomic characters. Species from arid regions appear to have more fibres. However, the taxonomic usefulness of the samara fibres requires further study.

ACKNOWLEDGEMENTS

The numerous institutes and individuals listed in the Appendix are thanked for the provision of seeds. The Monash Department of Ecology and Evolutionary Biology is thanked for the provision of facilities for the work, which was carried out by YH during the course of study for a Ph.D.

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Appendix

Part 1. List of seed specimens; species marked with * are placed by Wilson and Johnson (1989) in *Allocasuarina.*

Species Name	No. in this Study	Seed Source: Source/ Collection Number	Seed Source: Locality (lat.-long)
Casuarina			
**acuaria*	60	NSS(1)	WA
**acutivalvis*	23	Kings Park	WA
	71	TSC	31.5-118.1, WA
	72	TSC(2)	32.5-118.5, WA
**campestris*	24	Kings Park	WA
**ssp. *campestris*	73	TSC	31.39-117.254, WA
*ssp. *eriochlayms*	74	TSC	29.56-121.7, WA
*ssp. *grossa*	75	TSC	32-121.4, WA
**corniculata*	25	Kings Park	WA
	76	TSC	32.5-118.48, WA
	77	TSC	31.7-120.12, WA
cristata	61	NSS	WA
	92	TSC	28.29-150.27, QLD
	93	TSC	31.43-148.4, NSW
cunninghamiana			
ssp. *cunninghamiana*	1-6	YH(3)	Monash campus, VIC
ssp. *miodon*	45	NT Herb.	NT
decaisneana	62	NSS	?
	78	TSC	23.45-132.41, NT
	79	TSC	22.48-131.57, NT
**decussata*	80	TSC	34.3-116, WA
	81	TSC	34.59-117.16, WA
**dielsiana*	82	TSC	29.3-117.1, WA
	83	TSC	29.17-116.53, WA

*distyla	55	JGC(4)354	Pretty Beach, NSW
	84	TSC	0-100, NSW
	85	TSC	0-100, NSW
equisetifolia	63	NSS	?
ssp. incana	94	TSC	23.13-150.48, QLD
ssp. equisetifolia	95	TSC	16.41-145.35, QLD
	96	TSC	11.36-110.37, Thailand
	97	TSC	19-110, China
*fraseriana	26-7	Kings Park	WA
glauca	104-7	YH(3)	Monash campus, VIC
helmsii	86	TSC	31.5-118, 33, WA
	87	TSC	32.1-121, 47, WA
*huegeliana	28	Kings Park	WA
	39	DS(5)	Ravensthorpe, WA
*humilis	29	Kings Park	WA
	37	DS	Esperance, WA
*inophloia	34	PIF(6)2224	mundubbera, QLD
*lehmanniana	30	Kings Park	WA
	36	DS	Esperance N., WA
	120	NSS	WA
*littoralis	10	JGC 283	Tynong, VIC
	11	JGC 277	Tooradin NW., VIC
	20	PIF 2146	Mt Perry, QLD
	35	PIF 2204	Mundubbera, QLD
	50	JGC 339	Toohey Forest, QLD
	52	JGC 351	L. Munmorah Res., NSW
	53	JGC 352	L. Munmorah Res., NSW
	56	JGC 355	Nowra S. NSW
*luehmannii	88	TSC	16.43-145.2, QLD
	89	TSC	16.49-145.23, QLD
*microstachya	31	Kings Park	WA
*monilifera	64	NSS	?
*muelleriana	12	JGC 291	Halls Gap S.W., VIC
	47	JGC 310	Meningie E., VIC
	49	JGC 312	Keith S., SA
	112-3	YH(3)	Monash campus, VIC
	115	JGC s.n.	Grampians, VIC
*nana	65	HGK(7)	NSW
*obesa	66	NSS	WA
	98	TSC	29.5-117.27, WA
	99	TSC	26.34-120.3, WA
oligodon	58	FCPNG(8)	Marawaka, PNG
*paludosa	13	JGC 292	Halls Gap NE, VIC
	14	JGC s.n.	VIC
	15	JGC 281	Dalar, VIC
*paradoxa	116	JGC s.n.	Grampians, VIC
*pinaster	32	Kings Park	WA
	67	NSS	WA
*pusilla	117	JGC s.n.	Grampians, VIC
	118	JGC 292	Grampians, VIC
	119	JGC s.n.	Grampians, VIC
*scleroclada	68	NSS	WA
*striata	40-4	BGA(9)	Kangaroo Is., SA
*tessellata	69	NSS	WA
	90-1	TSC	29.28-117.18, WA
*thuyoides	38	DS	Esperance N., WA
*torulosa	16	JGC s.n.	VIC
	21	PIF 2113	Mt Perry, QLD
	22	PIF s.n.	Cooloola, QLD
	101-3	YH(3)	Monash Campus, VIC

**trichodon*	70	NSS	WA
**verticillata*	108-11	YH(3)	Monash campus, VIC
	108-11	YH(3)	Monash campus, VIC

(1) NSS - Nindethana Seed Service, Woogenilup, WA
(2) TSC - Tree Seed Centre, CSIRO, Canberra
(3) YH - Y.H. Hwang, Monash University
(4) JGC - J.G. Conran, Monash University
(5) DS - Dianne Simmons, Victoria College
(6) PIF - P.I. Forster, University of Queensland
(7) HGK - H.G. Kershaw Co., Terry Hills, NSW
(8) FCPNG - Forest Commission, Papua New Guinea
(9) BGA - Botanic Garden, Adelaide
NSW = New South Wales
QLD = Queensland
TAS =Tasmania
WA =Western Australia
NT =Northern Territory
SA =South Australia
VIC =Victoria
PNG =Papua New Guinea

Part II. Time period to the first germination.

Specimen Number	Days	Specimen Number	Days	Specimen Number	Days
1	5	43	9	84	7
2	5	44	11	85	7
3	5	45	6	86	10
4	5	47	16	87	6
5	5	49	12	88	8
6	5	50	8	89	8
10	6	52	6	90	6
11	7	53	5	91	6
12	15	55	5	92	9
13	12	56	5	93	9
14	11	58	7	94	15
15	6	60	18	95	15
16	5	61	11	96	15
20	5	62	4	97	15
21	6	63	18	98	7
22	11	64	9	99	7
23	12	65	9	101	6
24	5	66	7	102	7
25	21	67	17	103	7
26	14	68	9	104	12
27	23	69	16	105	9
28	6	70	9	106	10
29	7	71	10	107	10

30	8	72	9	108	6
31	6	73	9	109	7
32	17	74	6	110	6
34	6	75	6	111	6
35	5	76	12	112	9
36	6	77	10	113	8
37	7	78	4	115	16
38	11	79	4	116	10
39	5	80	14	117	9
40	14	81	14	118	19
41	11	82	4	119	13
42	11	83	4	120	21

DRAGONFLIES FROM THE WESTERN KIMBERLEY REGION

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INTRODUCTION

This paper provides a list of the dragonflies and damselflies (Odonata) collected during a five week visit to the west of the Kimberley region in April/May 1988. Information on habitats, local abundance, national distributions and some comments on the ecology and behaviour of some of the more interesting species are also presented. The visit was made between 7 April and 13 May 1988 as part of the Kimberley Research Project, an Anglo-Australian multi-disciplinary project designed to investigate aspects of the biology and geomorphology of the region. The study area contained parts of the Oscar, Napier and King Leopold Ranges and extended from Fitzroy Crossing (125° 32'E, 18° 11'S) in the south and east, to Lennard River/Gibb River Road (124° 45'E, 17° 24'S) in the west, and Beverley Springs (125° 28'E, 16° 43'S) in the north.

SPECIES AND DISTRIBUTIONS

A total of 32 species was collected, of which 14 were damselflies (Sub-Order Zygoptera) and 18 were dragonflies (Sub-Order Anisoptera). Table 1 lists the species and the habitat types from which they were collected, together with a rough index of abundance. Watson (1974) listed 53 species of odonates from the Kimberley region, and Watson (1977) added a further 4 species. Four species were collected which did not appear among the 57; they were *Agriocnemis argentea, Argiocnemis rubescens, Austroagrion pindrina* and *Austrosticta fieldi*. Of these, the first two have been recorded in the Kimberley region since 1977 (Dr. J.A.L. Watson, pers. comm.), but the third, *Austroagrion pindrina,* is the first record of this species outside the Pilbara region. A mating pair was collected in Brooking Gorge in the Oscar Range (125° 32'E, 18° 1'S) on 18 April. A long series of *Austrosticta* was collected. The specimens were essentially *A. fieldi*, but tended to bridge the